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G4020 SITE LIGHTING

RECORD OF REVISIONS

Rev	Date	Description	POC	OIC
0	6/28/99	Rewritten and reformatted to support LIR 220-03-01. Superseded Facilities Engineering Standards, Volume 7, Electrical, Manual Rev 15, 6/26/98.	David Powell, *PM-2*	Dennis McLain, *FWO-FE*
1	11/18/02	General revision and addition of endnotes. Replaces Subsection 252.	David Powell, *FWO-SEM*	Kurt Beckman, *FWO-SEM*
2	10/27/06	Added requirement for compliance with IESNA/ASHRAE 90.1; added detail to calc requirement; updated spec references; clarified pole grounding; added energy conserving controls for parking garage lighting; updated codes and standards; updated list of major and collector roads; deleted security lighting now in Ch 9; IMP/ISD changes.	David Powell, *FME-DES*	Kirk Christensen, *CENG-OFF*
3	5/12/10	Changed document number from ISD 341-2 to PD342; established lower limit in lumens for applicability of the New Mexico Night Sky Protection Act; required calculations to be in accordance with Z10; required use of LED luminaires; referenced design wind conditions for pole selection criteria; updated reference standards.	David Powell, *ES-DE*	Larry Goen, *CENG-OFF*

G4020 SITE LIGHTING

1.0 CRITERIA

1.1 General

A. Design exterior, roadway, parking facility, and security lighting that will promote safety and security, conserve energy, and preserve the environment.

B. Each exterior luminaire with light source exceeding 6400 lumens[1] shall comply with the New Mexico Night Sky Protection Act. *Exceptions to the Act may be granted by the Chapter 7 POC on a case-by-case basis for special situations.*

C. Select, locate, and aim luminaires to minimize the unintentional illumination of adjacent terrain[2] and so that glare is not directed towards any guard station.

1.2 Exterior Lighting

Design exterior lighting systems (e.g. safety and landscape lighting) according to Chapter 21 of the IESNA *Lighting Handbook*.[3]

1.3 Roadway Lighting

A. Design roadway lighting systems in accordance with IESNA RP-8 (ANSI)—*Roadway Lighting* and Chapter 22 in the IESNA *Lighting Handbook*.[4]

B. Determine the appropriate maintained luminance and illuminance for roadways using Figure 22-8 in the IESNA *Lighting Handbook.*

C. Use the following roadway classifications as the basis for determining the appropriate maintained luminance and illuminance for roadways:[5]

1. **Major** (Arterial in ESM Chapter 3, Section G20): The parts of the roadway system that serve as the principal network for through traffic flow. Major roadways at LANL are limited to:

   a. East Jemez (from Diamond Drive to NM4)
   b. West Jemez Road (from NM4 to Diamond Drive)
   c. Pajarito Road (from Diamond Drive to NM4)
   d. Diamond Drive (from Los Alamos Canyon Bridge to Pajarito Road)

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[1] 6400 lumens corresponds to the output of a 70 watt HPS lamp. The lower limit of applicability of the New Mexico Night Sky Protection Act is 70 watts of HID. The Act regulates outdoor night lighting fixtures to preserve and enhance the state's dark sky while promoting safety, conserving energy and preserving the environment for astronomy. Highlights of the act at http://www.rld.state.nm.us/cid/news/highlights of night sky protection act.pdf. The official text of the act is at www.michie.com/newmexico/lpext.dll?f=templates&fn=fs-main.htm&2.0 by following the links to New Mexico Statutes, Statutory Chapters in New Mexico Statutes Annotated 1978, Chapter 74, Article 12

[2] *IESNA Lighting Handbook*, "Light Trespass" in Chapter 21 of the ninth edition

[3] *IESNA Lighting Handbook*, Chapter 21 in the ninth edition

[4] *IESNA Lighting Handbook*, Chapter 22 in the ninth edition

[5] *IESNA Lighting Handbook*, "Classification Definitions" in Chapter 22 of the ninth edition, and ESM Chapter 3, Section G2010 (Para 2.0 in Rev. 2)

2. **Collector**: These are roadways used mainly for the main traffic movement within developed areas. The following principal roadways within highly developed parts of LANL technical areas are classified as collector roadways.
   a. Pecos Road
   b. Anchor Ranch Road
   c. La Mesita Road
   d. Two Mile Mesa Road
   e. Mercury Road
   f. R-Site Road
   g. Eniwetok Drive
   h. TA-22 Connection Road
   i. Puye Road
   j. Sigma Road
   k. Bikini Atoll
   l. West Road
   m. Pajarito Road (from West Jemez to Diamond Drive)
   n. Potrillo Road

3. **Local**: Roadways used primarily for direct access to facilities within developed LANL technical areas; they do not include roadways carrying through traffic.

D. Use the following area classification (abutting land use) as the basis for determining the appropriate maintained luminance and illuminance for roadways:

1. **Residential** (characterized by few pedestrians at night):[5] All developed LANL Technical areas.
2. **Rural:** All undeveloped areas.

E. Except for intersections, roadways in rural areas at LANL are generally not illuminated.

F. Illuminate the following intersections in accordance with Chapter 22 in the IESNA Lighting Handbook; illuminance and luminance shall be not less than the sum of the recommended values associated with each roadway that forms the intersection:[6]

1. Intersections of major, collector, and local roadways in "residential" areas (developed LANL Technical Areas).
2. Parking lot and high volume driveway connections to roadways in "residential" areas (developed LANL Technical Areas).
3. Isolated intersections [5] of major roadways and major roadways in rural areas.
4. Isolated intersections of collector roadways and major roadways in rural areas.
5. Isolated intersections of collector roadways and collector roadways in rural areas.

1.4 Pedestrian Walkway Lighting

A. Design pedestrian walkway lighting systems in accordance with Chapter 22 in the IESNA *Lighting Handbook*.[7]

[6] *IESNA Lighting Handbook*, "Situations Requiring Special Consideration" in Chapter 22 of ninth edition.

B. Limit power density to that permitted in ASHRAE/IESNA Standard 90.1[8].

1. Walkways less than 10 feet wide: 1.0 W/linear foot
2. Walkways 10 feet wide or greater: 0.2 W/ft^2
3. Plaza areas: 0.2 W/ft^2

1.5 Parking Facility Lighting

A. Design lighting systems for parking lots and parking structures in accordance with the IESNA *Lighting Handbook (Chapter 22*).[9]

1. Use "basic" illuminance selection criteria[10].
2. Use available day lighting in conjunction with artificial illumination to obtain the "day" illuminance recommended for parking garages[11].

B. Limit power density to that permitted in ASHRAE/IESNA Standard 90.1[12].

1. Uncovered parking lots: 0.15 W/ft^2
2. Parking garages: 0.3 W/ft^2

1.6 Calculations

A. Perform lighting calculations in accordance with ESM Chapter 1 Section Z10; use procedures outlined in the IESNA *Lighting Handbook*.

1. Use point-by-point calculation methods for exterior applications.[13]
2. In each calculation indicate the selected design maintained illuminance value and the factors[14] used for such selection such as:
   - Roadway classification
   - Adjacent area classification
   - Pavement classification
   - Uniformity ratio
   - IESNA *Lighting Handbook* referenced figure or table.
3. Detail the logic for any departure from the recommenced values in the IESNA *Lighting Handbook*.
4. Indicate the light loss factors used in the calculations and the underlying logic for their selection.
5. Indicate the calculated average initial and maintained illuminance based on the installed system. Calculated average "maintained" illuminance for the installed system shall be within 10 percent of the IESNA recommended illuminance value.[15]

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[7] *IESNA Lighting Handbook*, "Pedestrian Walkways and Bikeways" in Chapter 22 of the ninth edition, and ESM Chapter 3, Section G2010 (Paragraph 2.0 of Rev. 2)
[8] ASHRAE/IESNA Standard 90.1 (*Table 9.4.5 in 2004*). IECC does not address exterior lighting.
[9] *IESNA Lighting Handbook*, "Parking Facility Lighting" Chapter 22 of the ninth edition.
[10] *IESNA Lighting Handbook*, Figure 22-21 in the ninth edition. The incidence of personal security or vandalism incidents at LANL does not warrant the "enhanced security" levels of illumination.
[11] *IESNA Lighting Handbook*, Figure 22-22 in the ninth edition.
[12] ASHRAE/IESNA Standard 90.1 (*Table 9.4.5 in 2004*)
[13] *IESNA Lighting Handbook*, Chapter 9 in the ninth edition.
[14] *IESNA Lighting Handbook*, Chapter 22 in the ninth edition.

6. Include catalog information and photometric data for luminaires and lamps selected.

B. Perform calculations to show that the installed exterior lighting system power does not exceed the "exterior lighting power allowance" developed in accordance with ASHRAE/IESNA Standard 90.1.[16]

1. Contracted design organization shall certify that the lighting system complies with the requirements of ASHRAE/IESNA Standard 90.1.[17]
2. Certification shall bear the seal and signature of the professional engineer in responsible charge of the lighting system design.[18]

2.0 LUMINAIRES

2.1 General

A. Use luminaires with cut-off type distribution for site lighting. Each exterior luminaire with light source exceeding 6400 lumens shall comply with the New Mexico Night Sky Protection Act and shall be constructed or shielded such that the light emitted by the luminaire is projected below a horizontal plane running through the lowest point on the luminaire where light is emitted.[19]

B. Use light emitting diode (LED) luminaires for site lighting:[20]

1. Use LED luminaires for new site lighting system designs.
2. Use LED luminaires for additions or modifications to existing site lighting systems.
3. When an addition or a modification to an existing lighting system (i.e. a parking lot, an intersection, or a street segment) exceeds 50 percent of the number of existing luminaires in the system, replace existing luminaires with LED luminaires.
4. Until January 1, 2012, high-pressure sodium (HPS) luminaires may continue to be used for repairs and replacements in existing site lighting systems. After January 1, 2012, replace or modify existing luminaires that require repairs (i.e. new lens or ballast).[21] *It may be cost-effective to modify some types of existing HPS luminaires to operate with LED light source and also comply with the New Mexico Night Sky Protection Act.*
5. Existing HPS luminaires may continue in service until luminaire repair or replacement is needed.

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15 Recommended practice in IESNA *Lighting Handbook*, Chapter 9 of the Ninth Edition.
16 ASHRAE/IESNA Standard 90.1 (Section 9.4.5 in 2004)
17 Certification by the design agency will be accepted instead of a detailed review of the compliance documents required in ASHRAE/IESNA Standard 90.1 (Section 4 in 2004).
18 Required by New Mexico Engineering and Surveying Practice Act (Chapter 61, Article 23 NMSA 1978).
19 Refer to the New Mexico Night Sky Protection Act.
20 Refer to DOE PNNL-SA-60645, "LED Application Series, Outdoor Area Lighting." Well-designed LED outdoor luminaires can provide the required surface illuminance using less energy and with improved uniformity compared to HID sources. LED luminaires may also have significantly longer life (50,000 hours or more compared to 15,000 to 35,000 hours), and better lumen maintain lumens. Other LED advantages include: they contain no mercury, lead, or other known disposal hazards; and they come on instantly without run-up time or restart delay. Payback on LED usage is estimated to be 5-7 years for LANL based on reduced energy, maintenance, and disposal costs. DOE O 430.2B (CRD 5.a) dictates that LANL achieve a 30% energy use reduction by 2015 (vs. 2003).
21 By January 1, 2012 LANL should have sufficient experience with LED luminaires to have selected a standard replacement model and should also have sufficient inventory of LED luminaires to make on-call replacements.

C. With approval of a variance, high-pressure sodium[22] (HPS) luminaires may be used for site lighting designs where LED luminaires are not practicable. *LED luminaires may not be practicable at mounting heights above 40 ft, or in corrosive locations, or in hazardous locations.*

D. On security lighting systems use LED luminaires (or, with approval of a variance, HPS luminaires with "instant re-strike lamps" or "hot re-strike igniters") and standby power sources to maintain illumination in the event of power interruptions.[23]

E. Minimize the number of lamp and ballast types on each project.[24]

F. Provide luminaires that are NRTL listed and labeled for their indicated use and location.

G. Select low-maintenance luminaire finishes such as natural aluminum, anodized aluminum, or polyester TGIC powder coat that are resistant to fading, chalking, and other changes due to aging and exposure to solar heat and ultraviolet light.

H. *To the extent practical, appearance of luminaires should be similar to existing lighting in adjacent buildings or areas.*

I. Install luminaires in accordance with NECA/IESNA/ANSI 501, *Recommended Practice for Installing Exterior Lighting Systems*.[25]

J. Refer to LANL Master Specifications Section 26 5600 - *Exterior Lighting* for luminaire materials and installation methods.

2.2 Site Luminaire Schedules

A. Provide luminaire schedules in design packages that unambiguously describe luminaires, poles, and accessories.

B. *Luminaire schedules should contain the following information for exterior lighting:*

- *Fixture type designation (e.g. "R")*
- *Quantity and Description of fixture (e.g. One 400 watt high pressure sodium floodlight with NEMA 6X5 type beam spread)*
- *Description of materials (e.g. Cast aluminum housing and tempered glass lens)*
- *Description of mounting (e.g. Adjustable knuckle type slipfitter)*
- *Description of fixture finish (e.g. Gray enamel finish)*
- *Description of ballast if applicable (e.g. 277V CWA ballast)*
- *Description (ANSI code where applicable) and quantity of lamps (e.g. 1- S51WA-400/C lamp)*
- *Description of accessories where applicable (e.g. Photocell in twist-lock socket)*

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[22] High-pressure sodium lighting provides good energy efficiency, long lamp life, acceptable color rendering, and short run-up and restart delay. Mercury vapor lightning is prohibited by the New Mexico Night Sky Protection Act. DOE M 5632.1C-1 requires full-spectrum lighting, eliminating monochromatic low-pressure sodium. Metal-halide lamps have unacceptably short life.

[23] Conventional high-intensity discharge lamps require several minutes for the arc to re-strike and for light output to regain full output after a momentary power interruption. High-pressure sodium lamps are available with double arc tubes that provide nearly instantaneous re-start in case of a power interruption. LED light sources come on instantly without any run-up time or restart delay.

[24] Minimizing the number of lamp and ballast types reduces the costs and inventory required to maintain a site lighting system.

[25] NECA/IESNA 501 is one of the *National Electrical Installation Standards*; it defines a minimum baseline of quality and workmanship for installing exterior lighting systems.

- *Description of pole where applicable (e.g. 40 ft. tapered round steel pole)*
- *Description of pole finish where applicable (e.g. Galvanized finish)*
- *Manufacturer and catalog number for fixture and pole (e.g. XYZ #ABCD- 1234 fixture on #LMN-98-76 pole)*

3.0 POLES

A. Specify poles rated to carry the fixtures, supports, and appurtenances per ESM Structural Chapter 5 Section II based on the IBC and ASCE. *Guidance: At time of writing, this required:*

1. *Exposure Category: C*
2. *Basic Wind Speed: 90 mph (3-second gust at 33 ft above ground, mean recurrence interval of 50 years)*
3. *Importance Factor: 1.00*

B. Select low-maintenance pole finishes such as galvanized steel, natural aluminum, anodized aluminum, or polyester TGIC powder coat that are resistant to fading, chalking, and other changes due to aging and exposure to solar heat and ultraviolet light. Avoid pole finishes that will require periodic painting.[26] *Wood poles treated with copper naphthenate per AWPA C4 may be used for temporary site lighting and for site lighting in rural areas.*

C. Design pole bases to carry the luminaire(s) and pole at the indicated height above grade in accordance with ESM Chapter 5 and AASHTO LTS-5 *Standard Specification for Structure Supports for Highway Signs, Luminaires, and Traffic Signals*.

D. Design roadway lighting pole installations to meet design criteria of AASHTO LTS-5. Roadway light poles shall have an impact attenuation feature (breakaway base). The device shall include protection for wiring and conduit at the base of the standard.

E. *To the extent practical, appearance of poles should be similar to existing poles in adjacent buildings or areas.*

F. Require installation of poles in accordance with NECA/IESNA/ANSI 501, *Recommended Practice for Installing Exterior Lighting Systems*.[25]

G. Refer to LANL Master Specifications Section 26 5600 - *Exterior Lighting* for materials and installation methods.

4.0 WIRING AND CONDUIT

4.1 Conduit

A. Specify conduit systems to contain low-voltage branch circuit wiring systems for site lighting.[27] *In general, schedule 40 PVC conduit may be used for underground site lighting wiring systems.*

B. Size conduits considering all conductor adjustment factors required by the NEC.

C. Indicate sizes of branch circuit conduits on the design drawings and any changes on the record as-built drawings.[28]

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[26] Higher initial cost of pole is recovered due to much lower maintenance costs.

[27] LANL institutional policy developed through observation and experience. Installation of wiring systems in raceway systems protects conductors and facilitates future wiring modifications.

D. Specify materials and installation methods described in LANL Master Specification 26 0533, *Raceways and Boxes for Electrical Systems*.

4.2 Wiring

A. Specify copper conductors that have been sized with consideration to adjustment factors for voltage drop, ambient temperature, raceway fill, harmonics, and future loading.[29] Aluminum conductors are not acceptable.[30]

B. Indicate on the construction or record as-built drawings the number and size of conductors in site lighting conduit runs. [28]

C. Specify minimum No. 12 AWG for branch circuit wiring.[31]

D. Design branch circuit conductors for 3 percent maximum voltage drop at full-connected load.[32] Use voltage drop calculation methods outlined in Chapter 3 of IEEE Std 141.

E. To the extent possible, make wiring connections and splices in lighting pole hand holes.[33]

F. Provide individual fusing for each luminaire. Use "breakaway" type fused connectors located in the pole handhole.[34]

G. Identify all branch circuit conductors at each accessible location using color-coding that is consistent with that on the site.[35] *For minor work[36] at existing facilities use wiring color codes that match existing color codes so long as National Electrical Code requirements for identifying grounded and grounding conductors are satisfied[37].*

H. Specify materials and installation methods described in LANL Master Specifications Section 26 0519, *Low Voltage Electrical Power Conductors and Cables*.

4.3 Grounding

A. Specify a 600 volt insulated (green) equipment-grounding conductor in each site lighting branch circuit raceway.[38]

1. Size equipment-grounding conductor per NEC section 250.122.
2. Connect equipment-grounding conductor to the grounding stud in the metal pole and the grounding terminal in each luminaire.

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[28] Accurate design and as-built documentation facilitates maintenance and future system modifications.
[29] Adjustments for raceway fill, ambient temperature, and harmonics are required in NEC Article 310.15.
[30] The New Mexico Electrical Code prohibits the use of aluminum conductors smaller than No. 2; this prohibition is extended to all conductor sizes at LANL.
[31] The use of minimum 12 AWG on branch circuits limits voltage drop.
[32] AHSRAE/IESNA Standard 90.1-2004 required the stated voltage drop design criteria in paragraph 8.4.1.
[33] Objective is to reduce or eliminate site lighting junction boxes.
[34] Fusing of individual luminaires will prevent the failure of a ballast from disabling an entire circuit. Breakaway fused connectors ensure that exposed conductors will not endanger people should a pole fall.
[35] Color coding of phase conductors facilitates wiring system voltage identification and the correct installation of equipment requiring a specific phase sequence or phase rotation.
[36] ESM Chapter 7, D5000, "Application of this Chapter" heading.
[37] NEC Sections 200.6 and 250.119.
[38] Installation of an insulated equipment-grounding conductor is recommended practice in clauses 8.4.5.3 and 8.5.3 of IEEE Std 1100-1999. Clause 2.2.3 of IEEE Std 142-1991 indicates that the use of a metal raceway as a grounding conductor supplemented by an equipment grounding conductor achieves both minimum ground fault impedance and minimum shock hazard voltage.

B. Specify bonding the grounding stud in each metal lighting pole to a local 10-ft. driven ground rod or other available ground such as a building lightning protection counterpoise.[39]

1. Use minimum 6 AWG copper cable connected with NRTL-listed grounding fittings.
2. Install ground cable so it will not be exposed to physical damage.
3. *Ground rod may be installed within the concrete foundation.*

C. Specify materials and installation methods described in LANL Master Specifications Section 26 0526, *Grounding and Bonding for Electrical Systems*.

4.4 Site Lighting Controls

A. Control site lighting so it is automatically turned on when ambient natural lighting becomes less than 1.6 times the illuminance design value or 1.5 footcandles, whichever is higher[40], and is automatically turned off when sufficient daylighting is available or the lighting is no longer needed.[41]

B. Control exterior lighting by means of photocell(s) and/or astronomical time switch(es) through HAND-OFF-AUTO selector switch(es) and lighting contactor(s) as follows:[42]

1. Safety, security, pedestrian walkway, and roadway: on at dusk and off at dawn – photocell controlled.
2. Parking facility and landscape lighting: on at dusk and off at preset time – photocell on, time clock off. A small percentage of parking lot lighting shall remain on until dawn for personnel security.
3. Parking garage lighting: on and off under photocell control to provide required day and night illuminance at entrance areas, ramps, and parking levels[43]. Include time clock to turn off the majority of the parking garage lighting at a preset time. A small percentage of parking garage lighting shall remain on until dawn for personnel security.

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[39] Purpose is lightning protection.
[40] *IESNA Lighting Handbook*, the Lighting Equipment heading Chapter 29 in the ninth edition. HID systems must be energized a sufficient time before darkness to so full lamp output will be available at darkness.
[41] ASHRAE/IESNA Standard 90.1 (Para 9.4.1.3 in 2004).
[42] *IESNA Lighting Handbook*, Lighting Equipment heading Chapter 29 in the ninth edition.
[43] *IESNA Lighting Handbook* (Figure 22-22 in ninth edition)